

# ***Leveraging ASTM Industry Standard F3269-17***

## ***Providing Safe Operations of a Highly Autonomous Aircraft***

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NASA / Armstrong Flight Research Center*

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*Professor  
University of Tulsa*

# Research Timeline

1980

2000

2010

2018

## Automated Maneuvering Attack System (AMAS)



Automation Research

## AFTI/F-16

Advanced Fighter Technology Integration

## AFTI & ACAT/F-16

Automated Collision Avoidance Technology

## Automated Collision Avoidance

Air



Ground



Integrated

## Dedicated Safety Work for Fighters

## Ground Collision Avoidance

Small UAS



GA



Quad-Rotor

Transition



## Platform Diversity

## SUAV/iGCAS/SR22

Improved Collision Avoidance System





# *Resilient Autonomy*

## **1. We began our work by developing an automatic ground collision avoidance system (GCAS) for fighters**

- Completed research in 2011
- Fielded in the USAF F-16 fleet 2014-15 / Fielded in the F-35 fleet late-2019
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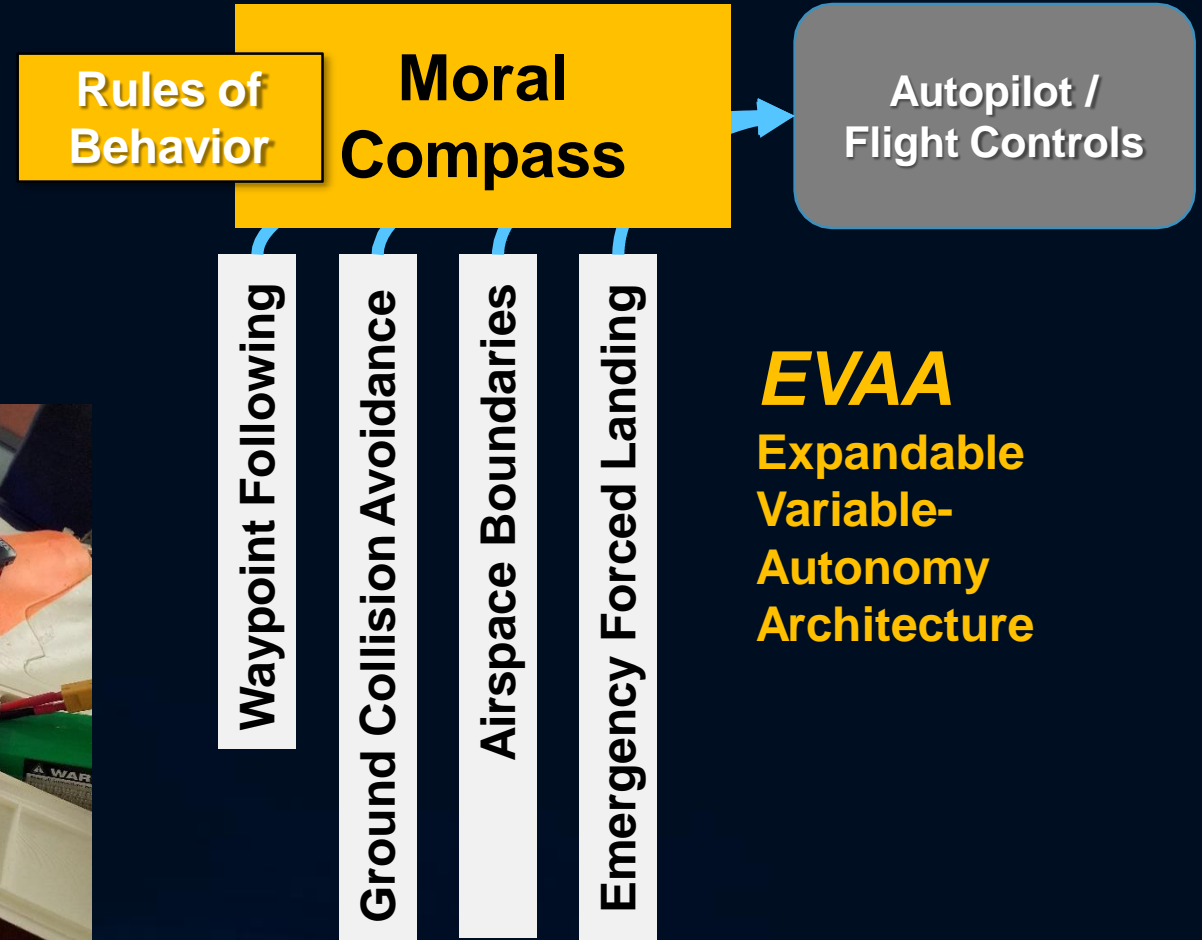
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# Broadening the Scope of Automatic Safety





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  - How to coordinate command/control of the vehicle: a multi-monitor run-time assurance architecture
  - First phase of expandable variable-autonomy architecture (EVAA)
  - Unique part of this research: **The Moral Compass & Rules of Behavior**
    - When Safety should take priority over the mission & when protecting human life should take priority over vehicle safety







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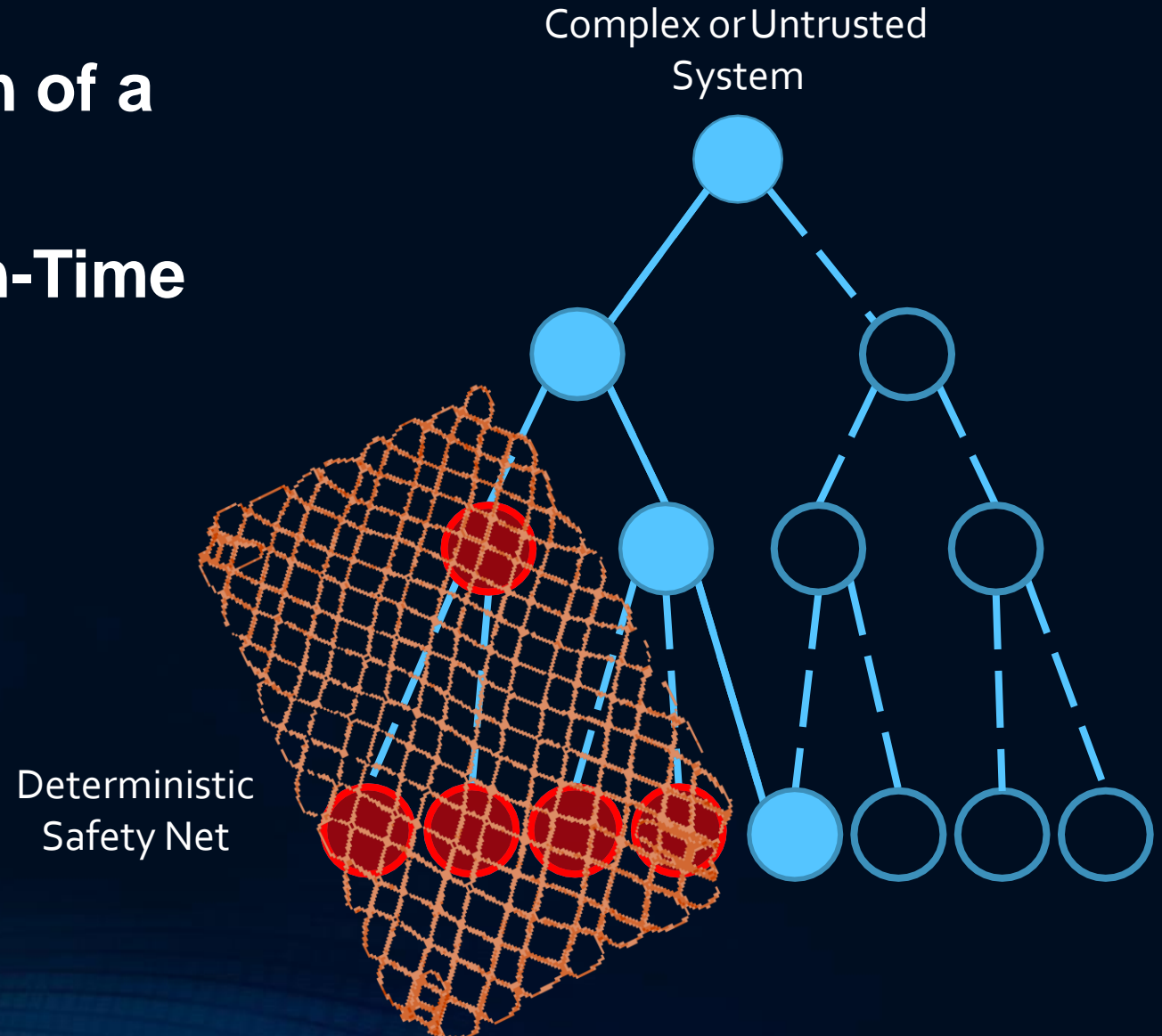
## 4. The FAA Heard of this work: "Eureka, You have found the golden ring for certifying autonomy"

- ASTM working group was established to capture EVAA concept
- Industry Standard was published October 2017 <https://www.astm.org/Standards/F3269.htm>



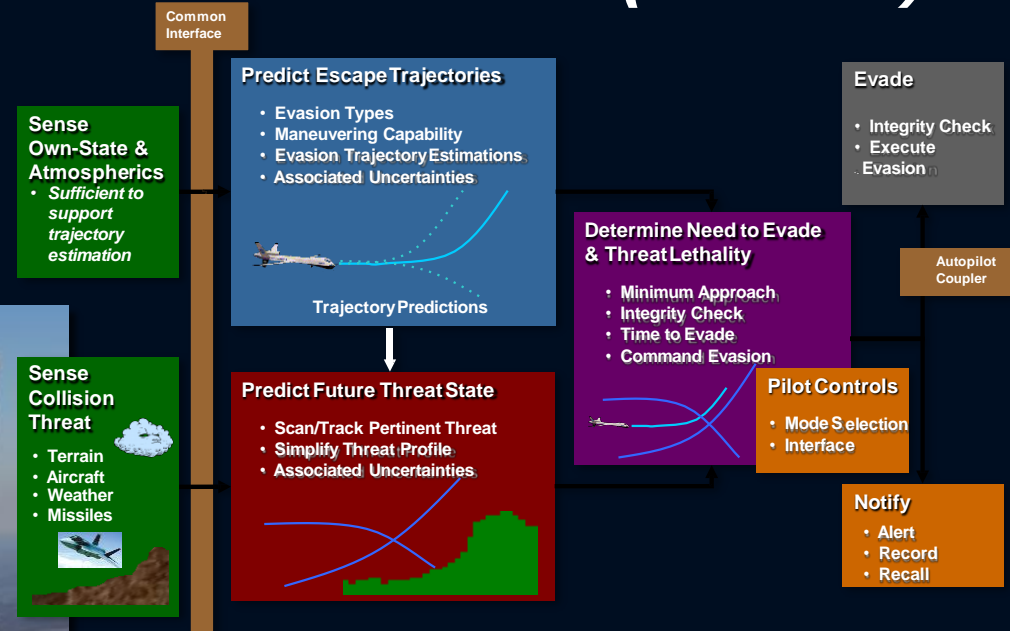
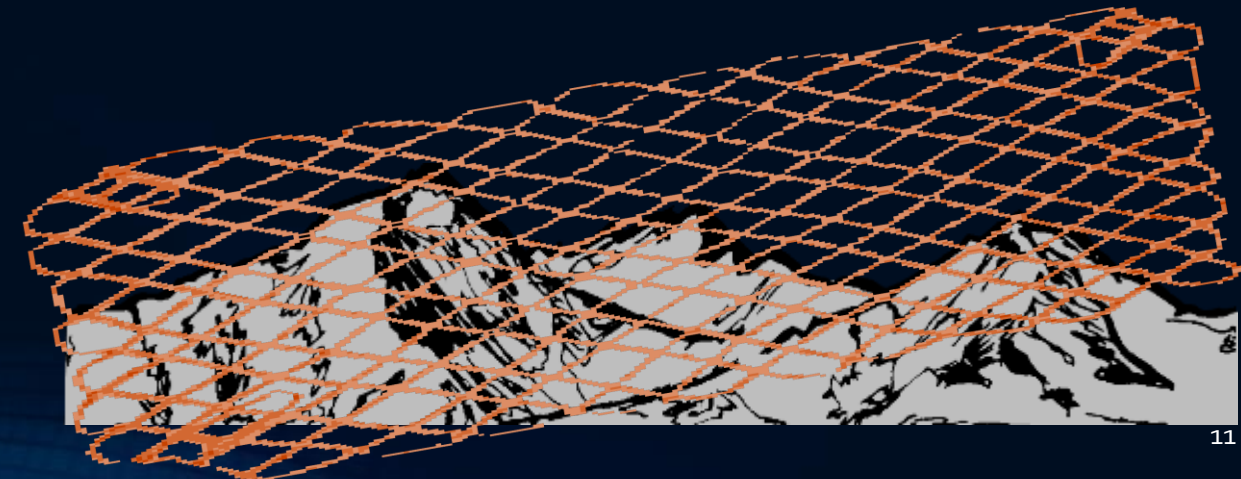
# *The Challenge of Autonomy*

- **Verification & Certification of a Complex System**
- **A Possible Solution – Run-Time Assurance (RTA)**



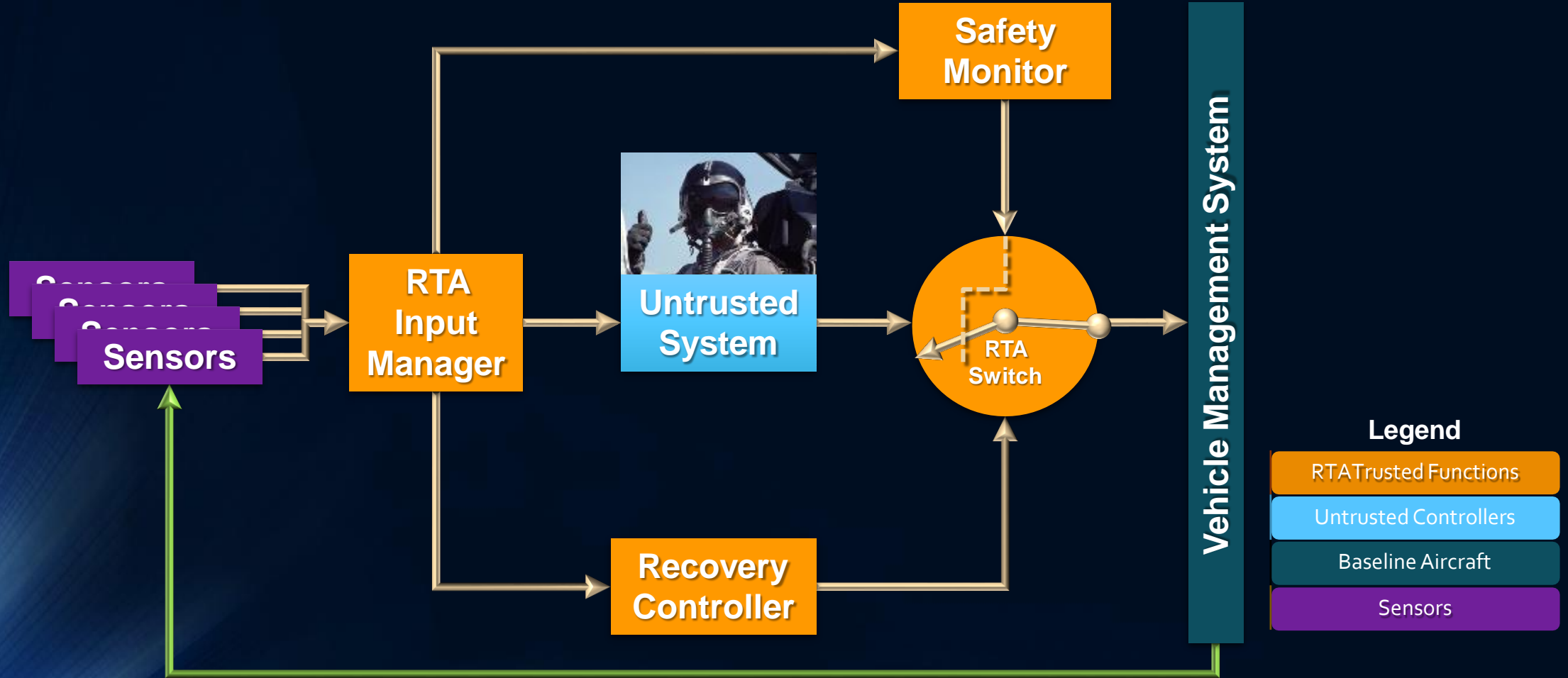


# Ground Collision Avoidance System (GCAS)



# Traditional RTA Framework

<https://www.astm.org/Standards/F3269.htm>



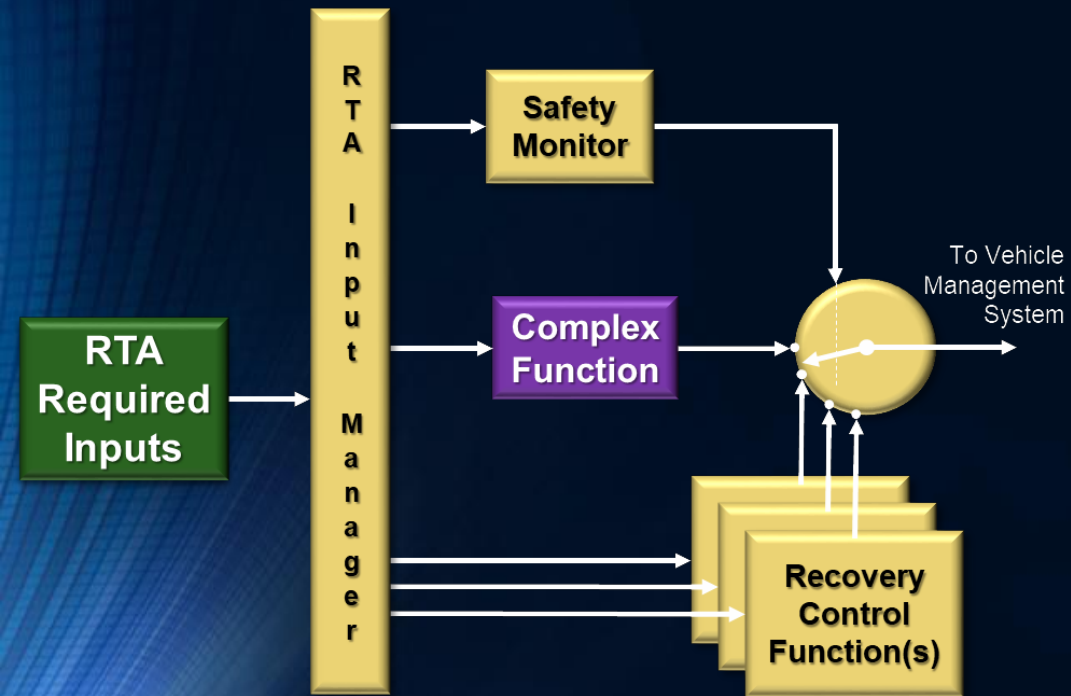


# Expandable Variable-Autonomy Architecture

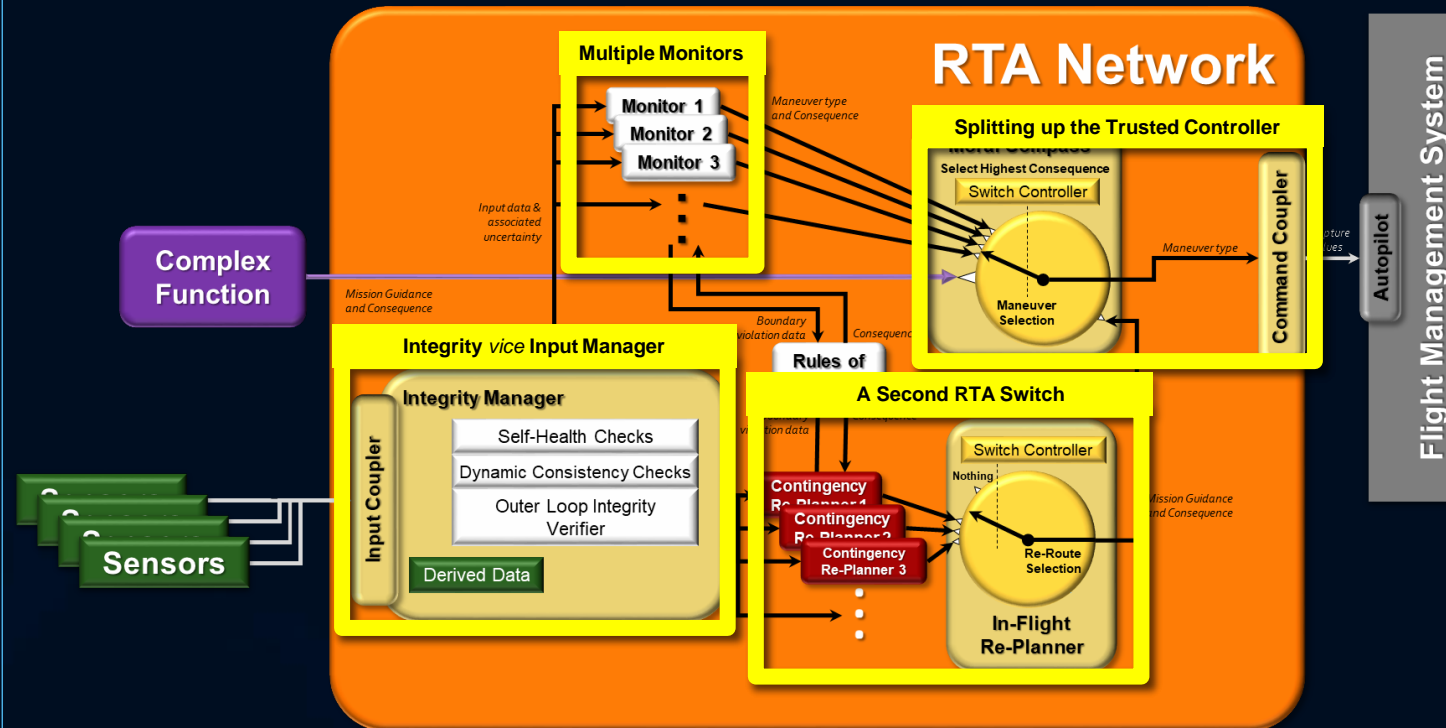


# Leveraging the ASTM Standard

ASTM F3269-17  
*Published Illustration*

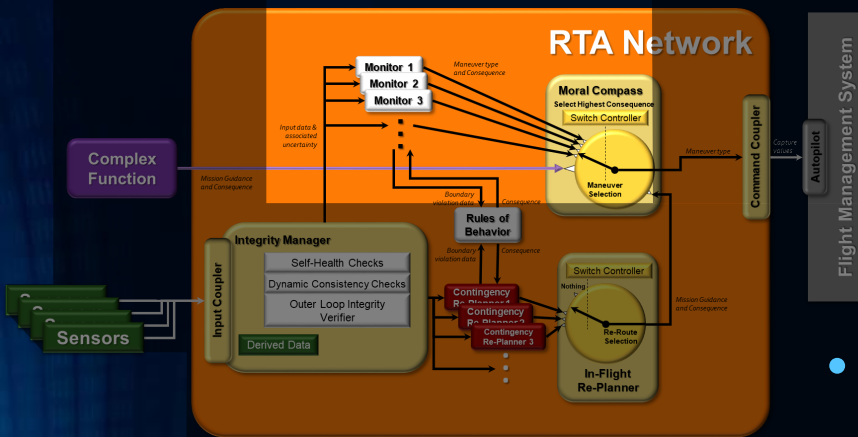


Leveraged Implementation  
*Resilient Autonomy*



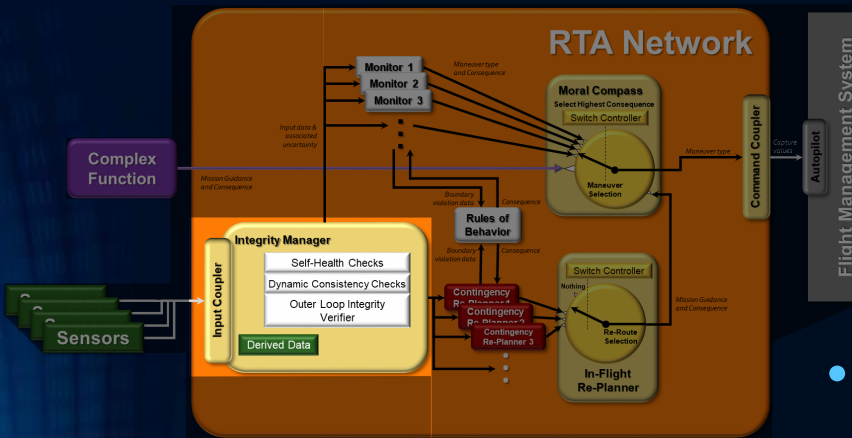


# Multiple Monitors



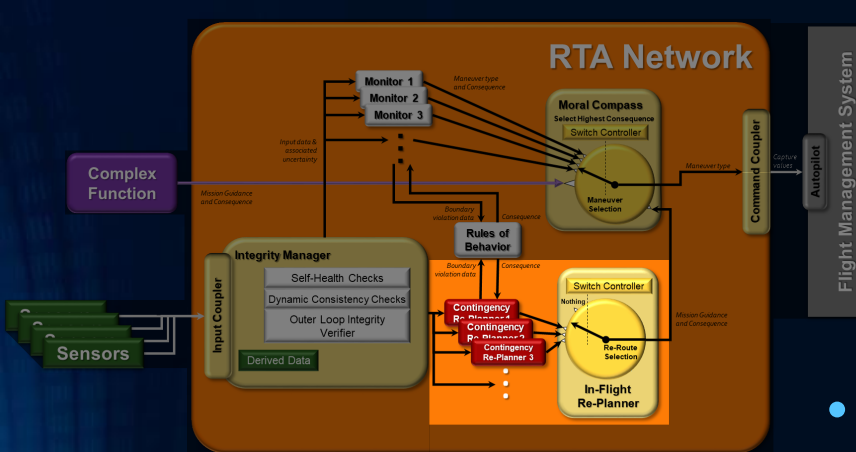
- **Understanding the different aircraft safety concerns and their connection to piloting tasks.**
- **Decomposition of piloting tasks with emphasis on safety and/or ops?**
- **Functional partitioning vs. single “mother of all” monitor (Why it makes sense to functionally partition)**
  - *Robustness of multiple simple systems vs. a single complex system*
  - *Ease of V&V*
- **The need for a multi-position RTA switch**
- **The need for consequence & therefore rules of behavior**

# Integrity Manager



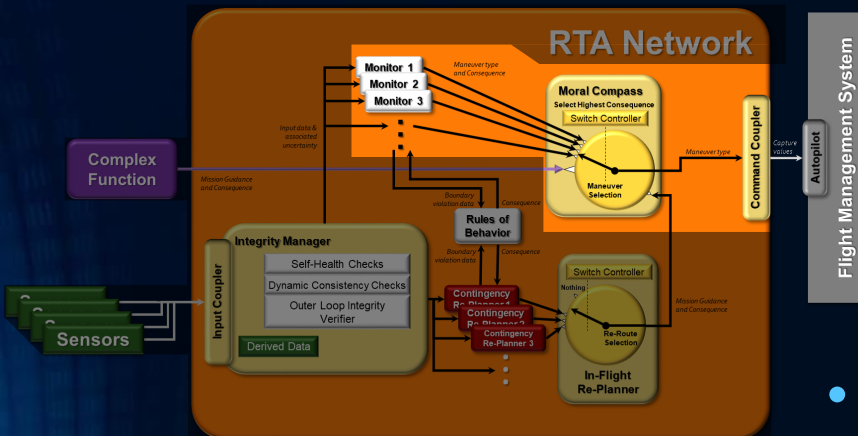
- *Integrity vs redundancy*
- *Integrity Monitors*
  - *Self-Health*
  - *Derived Inputs*
  - *Dynamic Consistency Checks*
  - *Outer-Loop Integrity Verification*





# A Second RTA Switch

- *Addressing what should be done when integrity degrades*
- *Allowing the safety monitors to still work under emergency conditions*
- *Certitude differences with emergency systems*



# *Splitting up the Trusted Controller*

- *Leveraging a pre-existing autopilot*
- *Monitors requesting a maneuver*
- *A command coupler translating a maneuver request*



# Resilient Autonomy

## Technology & Airworthiness Development & Transition

Performance Based Certification

F-16 Auto GCAS & ACAS



AvSP



1<sup>st</sup> Industry Standard



UTM & SASO



Resilient Autonomy



2018 Collier

Reference Implementation Development

NASA



Industry



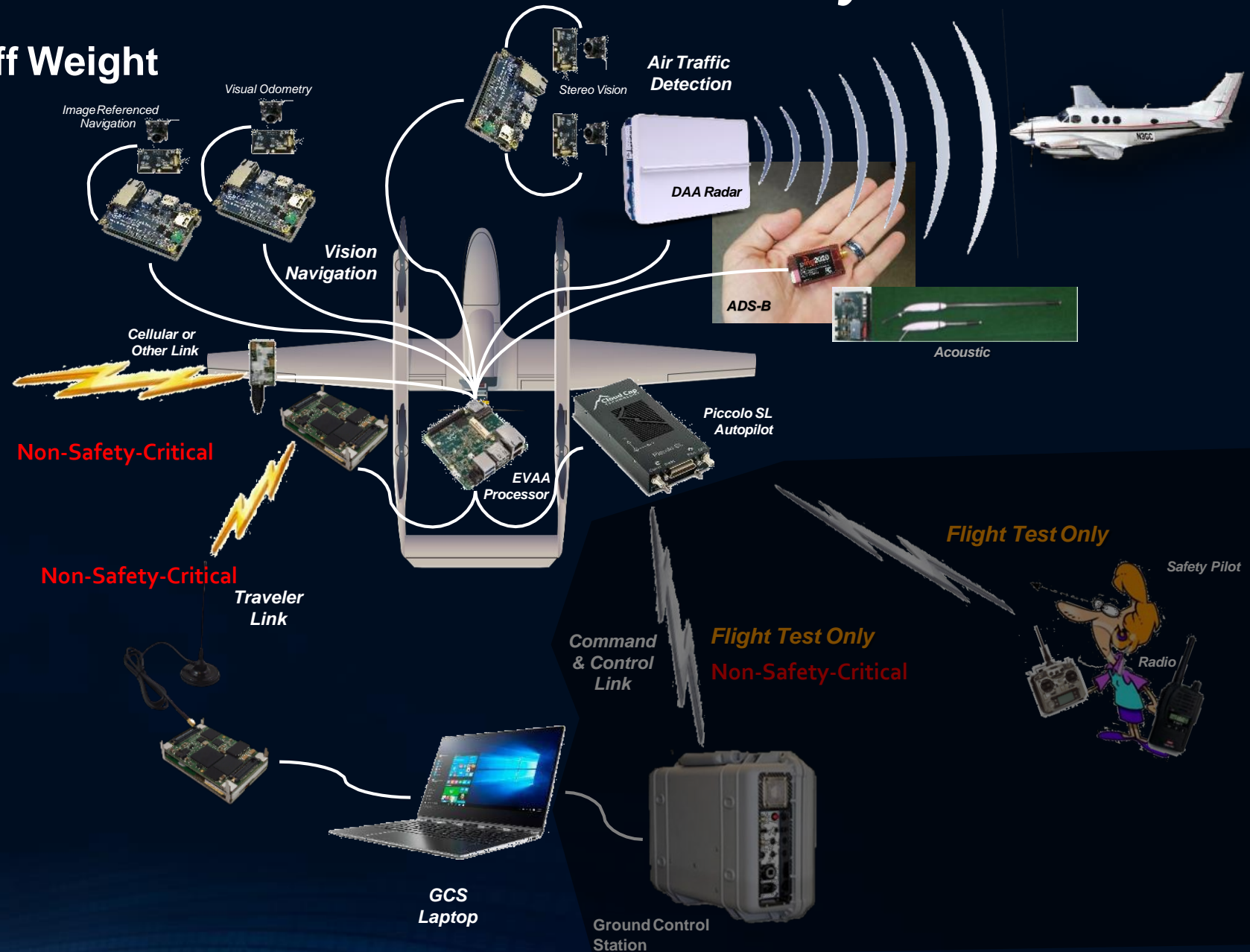
Autonomy  
Safety  
Standards

DoD



# Resilient Autonomy EVAA/HQ-90

- 115 Lbs. Max Gross Takeoff Weight
- 14' 8" Wingspan
- 27 Pound Payload
- 12 Hour Endurance



Non-Safety-Critical

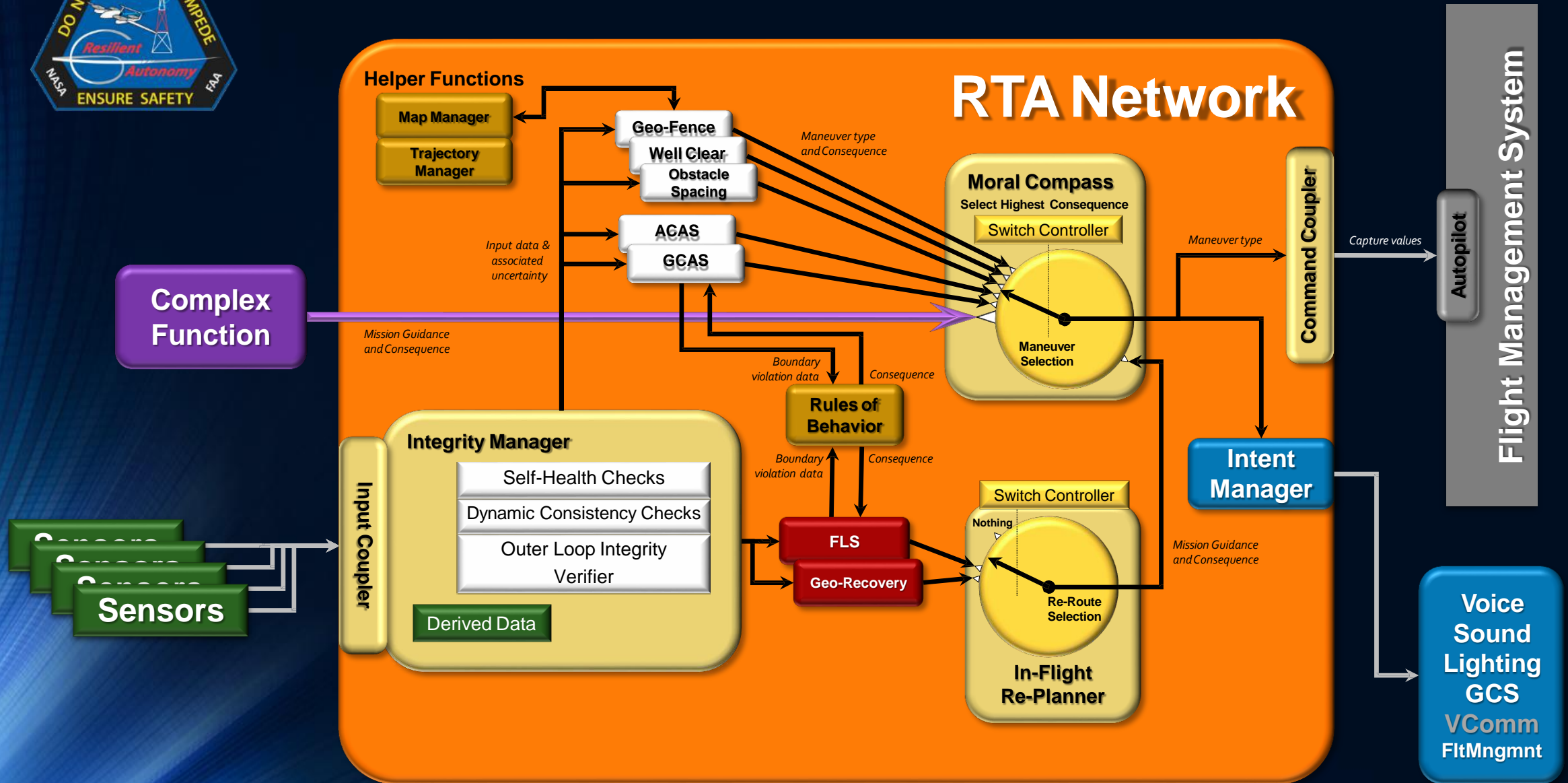
Big  
Data

Global Terrain &  
Obstacle Data Bases  
Weather  
Etc.





# RTA Network Architecture





*Questions*

